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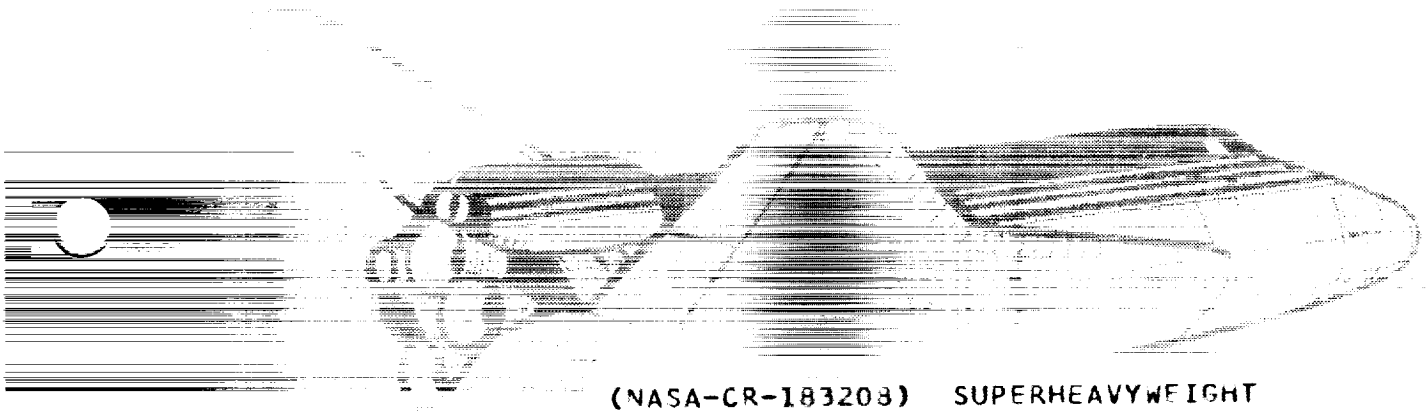
STSOC-RT-001283

171823
p. 40

SUPERHEAVYWEIGHT MISSIONS SI vs DI ASCENT FLIGHT DESIGN OPTIONS AND RECOMMENDATIONS

October 26, 1990



(NASA-CR-183208) SUPERHEAVYWEIGHT MISSIONS SI VERSUS DI: ASCENT FLIGHT DESIGN OPTIONS AND RECOMMENDATIONS (Rockwell Space Operations Co.) 40 p

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Systems Management American Corporation

STSOC TRANSMITTAL FORM

NO. 330-330-128

DATE: September 27, 1990

TO: L. Davis /DM2

FROM: M. Elsperman / RSOC

SUBJECT: SI vs DI Trade Study Results for STS-50 and Generic EDO Missions (Superheavyweight)

PURPOSE:

AFD has completed the trade study on Standard Insertion (SI) vs Direct Insertion (DI) for STS-50. RSOC Range Safety has developed acceptable DI targets from 130 n.mi. to 150 n.mi. and the corresponding performance assessment for these targets using STS-50 data has been completed. This mission has sufficient performance capability to perform this mission as a DI to 160 n.mi. A reduced OMS load corresponding to a DI mission is required for this option. The increase in altitude over the AFP baseline (SI to 145 n.mi.) is highly desirable for this mission. The orientation on orbit for the orbiter/USML-1 payload is such that orbital decay is maximized (maximum frontal cross-sectional area with vehicle normal to velocity vector). Increasing the operational altitude reduces the amount of vernier thruster firings necessary to maintain a constant gravity gradient. The results of this trade study can also be applied to other superheavyweight missions (EDO flights) and will allow for use of the DI technique for lower orbital altitudes, thereby eliminating the SI option for due east, low altitude missions. STSOC transmittal form no. 330-330-130, which documents the technical issues and assumptions used for this trade study effort in detail, should be referenced for further information.

The main reason that a DI is desired for STS-50 and other superheavyweight flights (low altitude) is that ESMC range safety has expressed reservations about SI missions in general. The concern is that the current SI design underspeed exposes Africa and Madagascar to potential ET debris impact. In the past range safety has waived the requirement that these areas be protected in the event of an engine failure. With the advent of the pre-MECO OMS dump, the viability of DI, and the high casualty expectations from the ACTA press to MECO hazard study, range safety has become more reluctant to approve SI flights. It is felt that to perform an SI mission there would have to be a large decrease in design underspeed to protect these landmasses, which would result in possible gaps between a late TAL and PTA. The assumed limit on a DI has been to altitudes greater than 160 n.mi. It was assumed that for altitudes less than 160 n.mi. the nominal ET impact envelope would overlap the Gilbert Islands.

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JSC FORM 650 (Rev May 86) (MOD Ethernet March 86)

(cont.)

However, no specific analysis had been performed to validate the assertion that DI to altitudes lower than 160 n.mi. was not acceptable. For mission planning purposes, DI was baselined for flights greater than or equal to 160 n.mi., and missions requiring lower altitudes would automatically use SI (past mission precedents). The generic DI limit of 160 n.mi provided a conservative constraint for mission planning. The generic DI 160 n.mi. MECO target provided adequate ET impact protection for the Gilbert Islands for all missions regardless of propellant residuals. This meant that for missions with large propellant residuals (≈60K) there would be sufficient clearance for the ET impact ellipse. For missions with lower amounts of propellant residuals (≈6K), the clearance would be even greater. Page 2 of Attachment 1, the DI MECO target lines, shows this trend.

The analysis performed by RSOC Range Safety showed that acceptable DI targets to altitudes less than 160 n.mi. do exist. Interpolating between the 6k and 60k residual/worst case guided MECO constraint lines allowed for shallower MECO flight path angles without impacting any landmasses. Dropping to the 6K constraint line assumes that any mission baselined for orbit altitudes less than 160 n.mi. would be performance critical. Attachment 1, page 3 shows the derived MECO target line extensions developed for this study.

MECO target line 1 represents an interpolation between the 60k residual line and the 6K residual line. The MECO targets from this line resulted in the acceptable ET impact points listed in Attachment 1, page 4. Page 5 lists the estimated clearance from the Gilbert Islands. These points and estimated uncertainty envelopes are graphically shown on pages 6-9.

MECO target line 2 is simply a small segment of the 60K residual line. The MECO targets taken from this line resulted in larger flight path angles at MECO, and corresponding impact locations uprange as compared to those from MECO target line 1. Page 4 lists the estimated impact points for MECO target line 2. The impact ellipse clearance from the Gilbert Islands is again listed on page 5 of Attachment 1, and graphically shown on pages 10-11.

The impact ellipse used in this analysis is somewhat more conservative than those used in the previous analyses (± 1200 n.mi. uprange/downrange, ± 50 n.mi. crossrange). Rupture and breakup altitudes assumed are consistent with the current ET certification working group recommendations (285K ft rupture, 214K ft breakup).

The results of this study indicate that based on the simulation data contained in the STS-50 AFP TDDP, DI to 160 n.mi. is feasible for STS-50 and should be examined in more depth during CFP. The generic conclusion of this study is that acceptable DI MECO targets to altitudes less than 160 n.mi. exist for performance critical (low residual) missions. This assumption is met for upcoming superheavyweight missions (EDO flights) in that the desired orbit altitude is being constrained by performance limitations. These guidelines provide a basis for superheavyweight mission planning and allow for elimination of the SI option for low altitude, due east flights.

ATTACHMENT 1

STS-50 ET DISPOSAL ASSESSMENT

ASSUMPTIONS

- Nominal and Worst Case Guided MECO (WCGM) disposal footprint size was approximated at:
  - 1200 nm Uprange
  - 1200 nm Downrange
  - 100 nm Crossrange
- Maximum ET rupture altitude of 285,200 feet.
- Maximum WCGM flight path angle error is -0.2 deg.
- Did not include azimuth deviation associated with engines #2 or #3 out.

CONCERNS

- Nominal performance to reach selected MECO target.
- Ascent heating enviroment given shallow flight path angle.
- Applicability of maximum WCGM flight path angle error of -0.2 deg.

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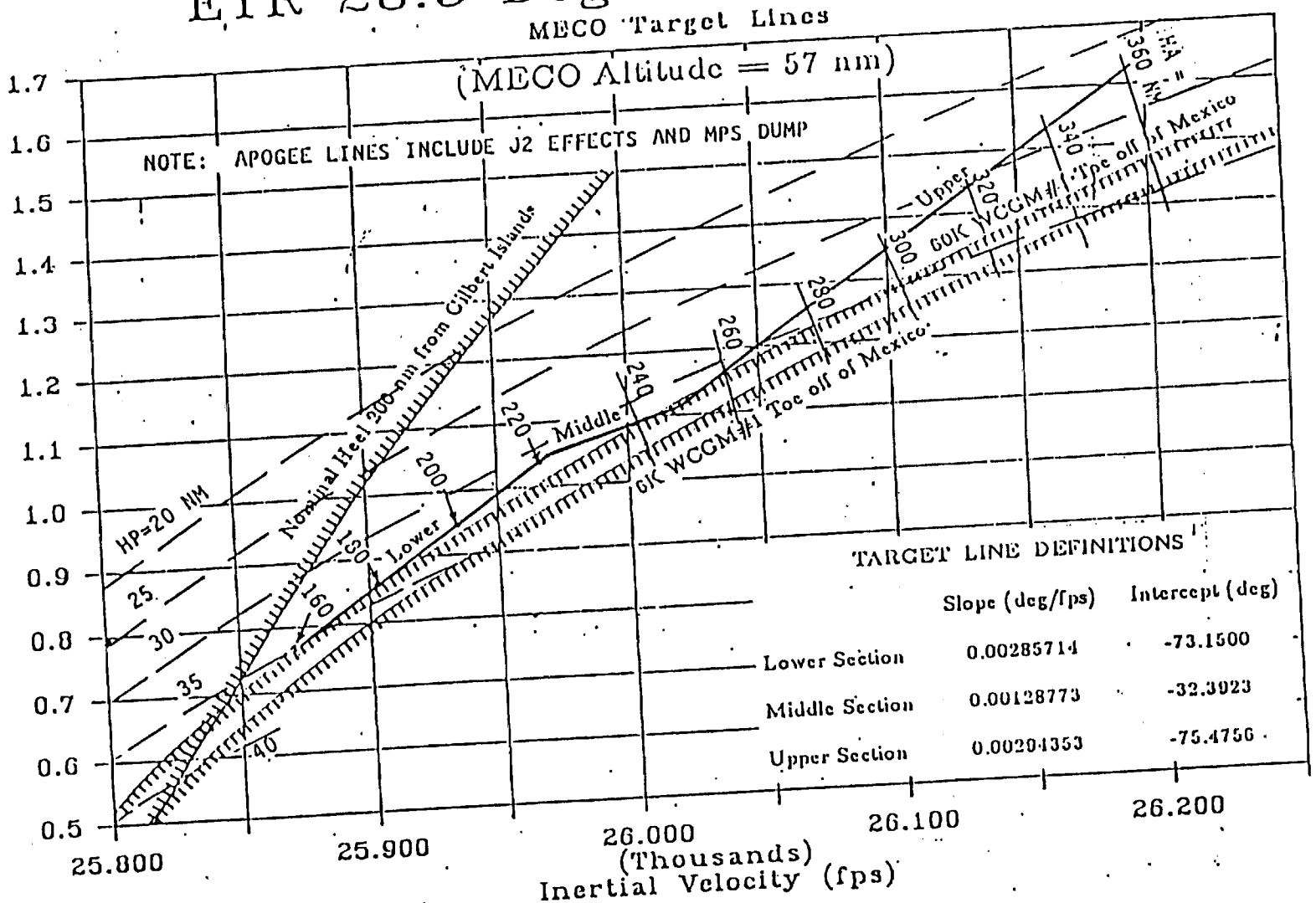
ETR 28.5 Deg Direct Insertion

MECO Target Lines

(MECO Altitude = 57 nm)



TARGET LINE DEFINITIONS

	Slope (deg/fps)	Intercept (deg)
Lower Section	0.00285714	-73.1500
Middle Section	0.00128773	-32.3923
Upper Section	0.00204353	-75.4756

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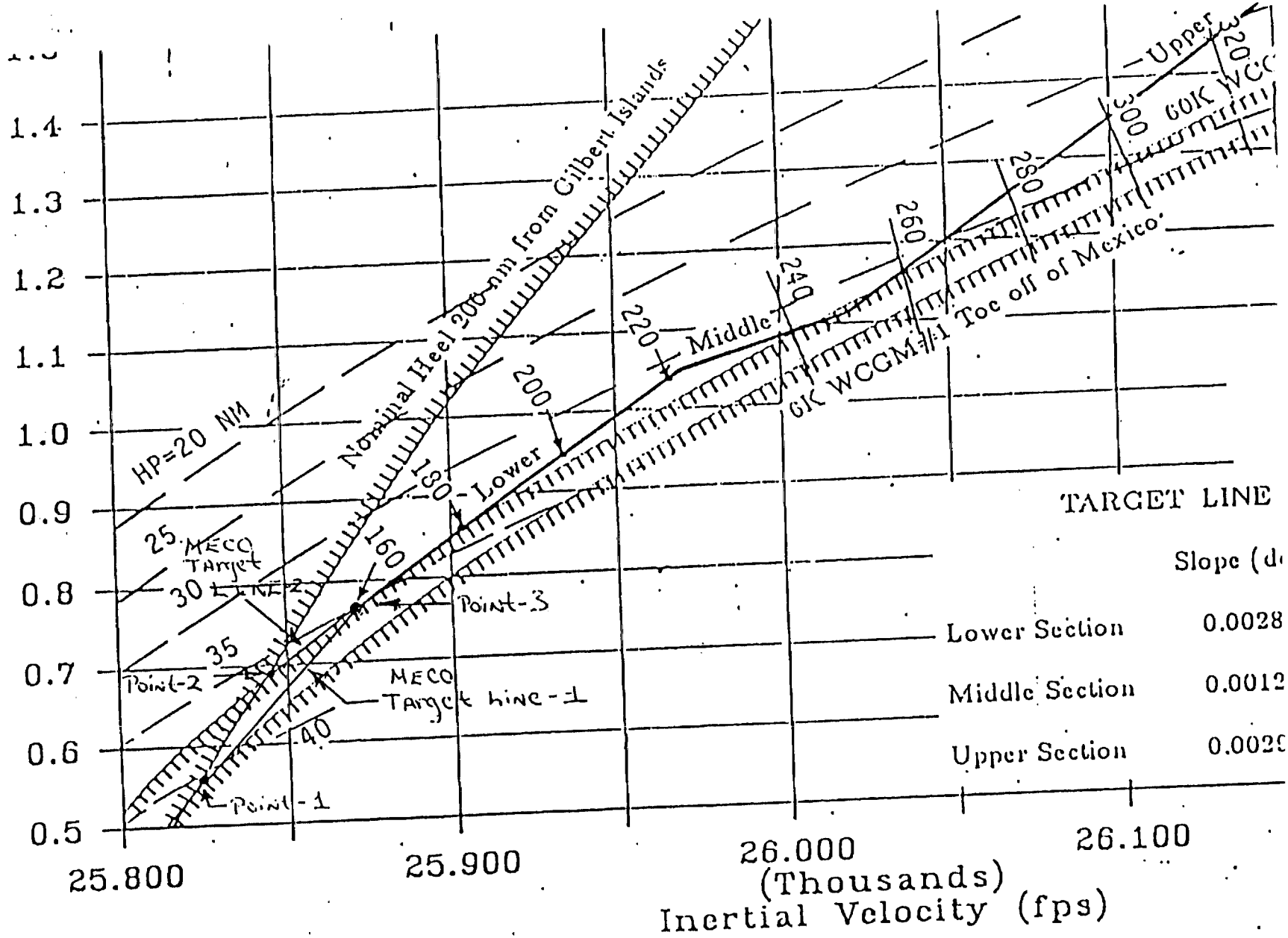
Inertial Flight Path Angle (d
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
25.800
25.900
26.000
26.100
(Thousands)
Inertial Velocity (fps)
HP=20 NM
Nominal Heel 200-nm from Gilbert Islands
Upper
Middle
Lower
60K WCGM-1 Toe off of Mexico
25
30
35
40
MECO Target LINE-2
MECO Target Line-1
Point-1
Point-2
Point-3
TARGET LINE
Slope (d
Lower Section 0.0028
Middle Section 0.0012
Upper Section 0.0029

MISSION STS-50 ET DISPOSAL EARLY ASSESSMENT FOR 28.5 Deg DIRECT INSERTIONS

TABLE-1: MECO TARGET LINE-1*

APOGEE ALTITUDE (nm)	VI (fps)	GAMI (deg)	NOMINAL IMPACT LONGITUDE (deg)	NOMINAL IMPACT LATITUDE (deg)	WCGM-A IMPACT LONGITUDE (deg)	WCGM-A IMPACT LATITUDE (deg)	WCGM-B IMPACT LONGITUDE (deg)	WCGM-B IMPACT LATITUDE (deg)
130	25,825.93	0.5634	195.4223	12.1429	226.3084	24.2517	185.6923	6.9433
140	25,840.75	0.6312	196.3076	12.6139	224.9220	23.8894	187.0953	7.7476
145	25,848.17	0.6651	196.4943	12.7192	223.8128	23.5843	187.5832	8.0290
150	25,855.58	0.6990	196.6055	12.7864	222.5923	23.2362	187.9957	8.2680

TABLE-2: MECO TARGET LINE-2*

APOGEE ALTITUDE (nm)	VI (fps)	GAMI (deg)	NOMINAL IMPACT LONGITUDE (deg)	NOMINAL IMPACT LATITUDE (deg)	WCGM-A IMPACT LONGITUDE (deg)	WCGM-A IMPACT LATITUDE (deg)	WCGM-B IMPACT LONGITUDE (deg)	WCGM-B IMPACT LATITUDE (deg)
145	25,845.38	0.6911	192.7092	10.7756	217.3973	21.5754	184.4514	6.2851
150	25,853.74	0.7162	194.1615	11.5432	218.5199	21.9600	185.9652	7.1453

MISSION STS-50 ET DISPOSAL EARLY ASSESSMENT FOR 28.5 Deg DIRECT INSERTIONS

TABLE 3

APOGEE ALTITUDE (nm)	MECO TARGET LINE-1* CLEARANCE BETWEEN NOMINAL FOOTPRINT HEEL AND THE GILBERT ISLANDS (nm)	MECO TARGET LINE-2* CLEARANCE BETWEEN NOMINAL FOOTPRINT HEEL AND THE GILBERT ISLANDS (nm)
130	258.03	-----
140	308.81	-----
145	349.77	108.16
150	349.77	201.23

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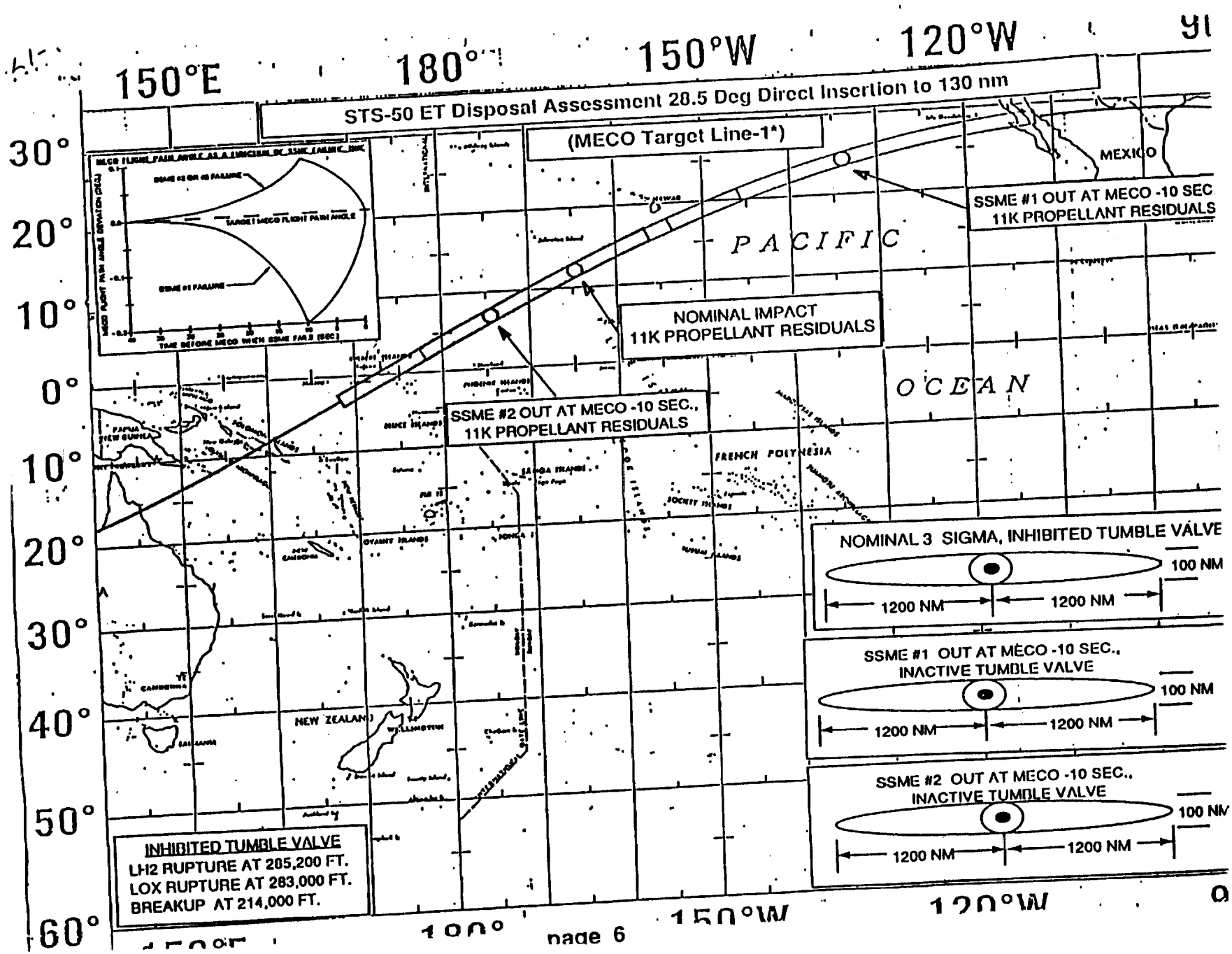

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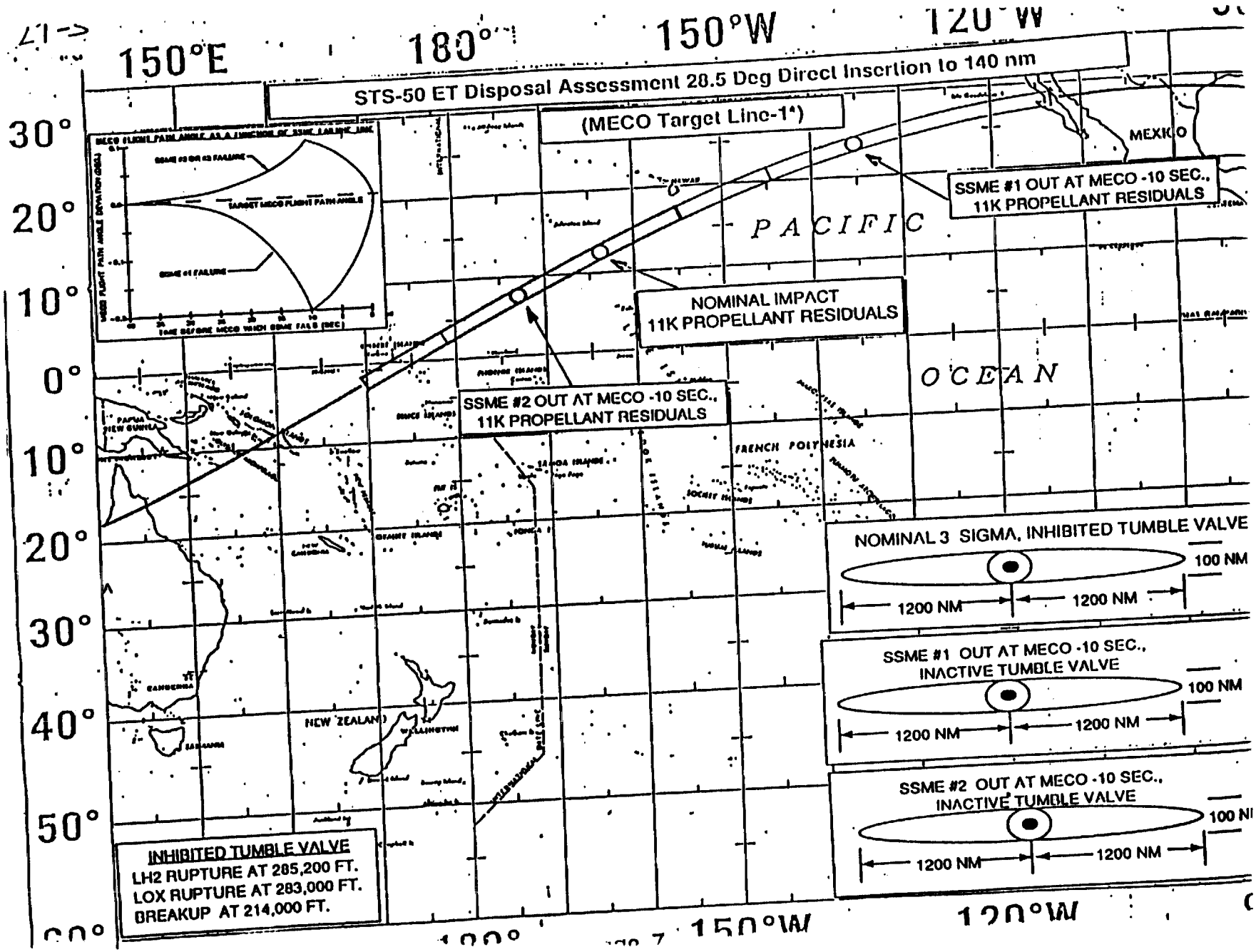
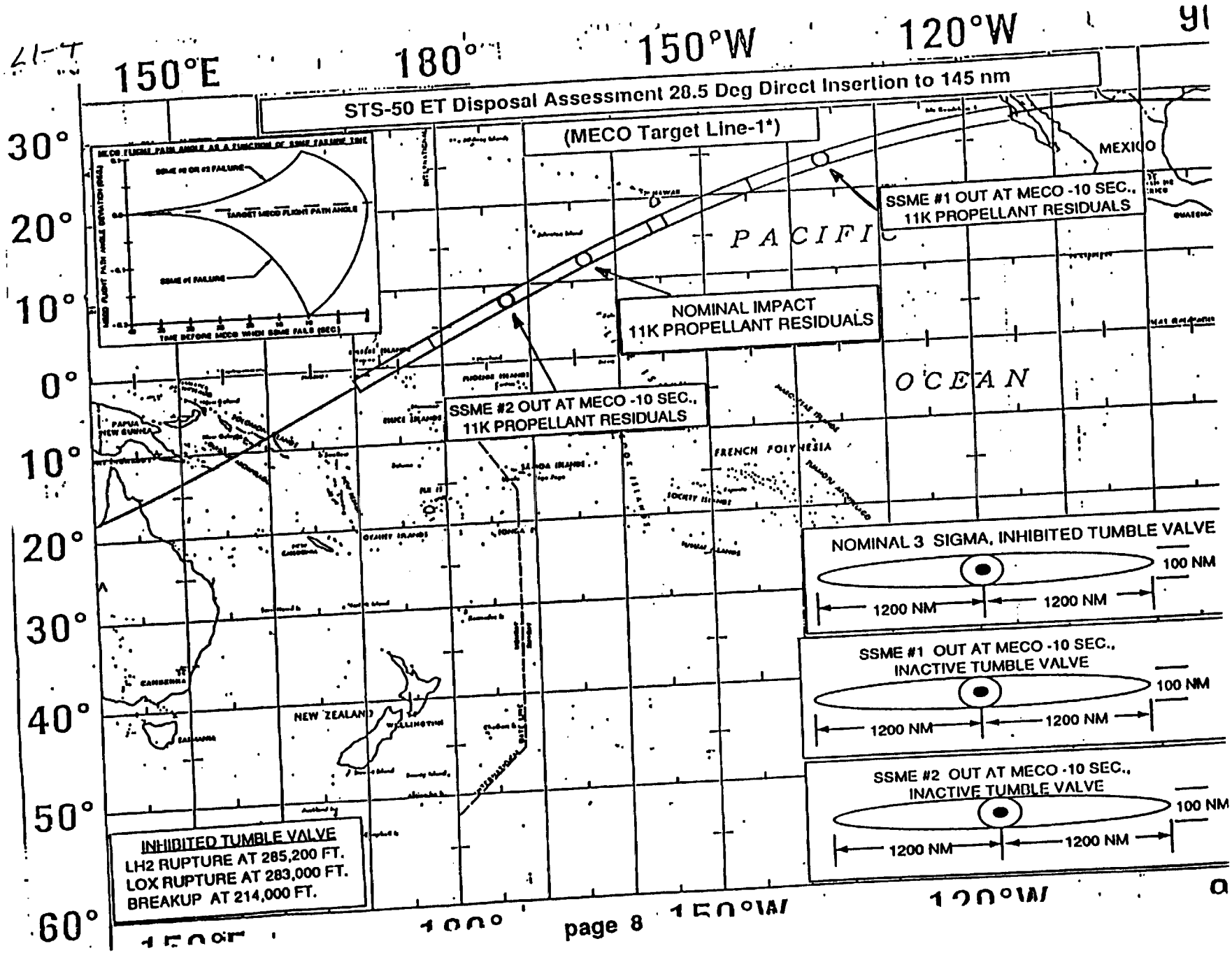
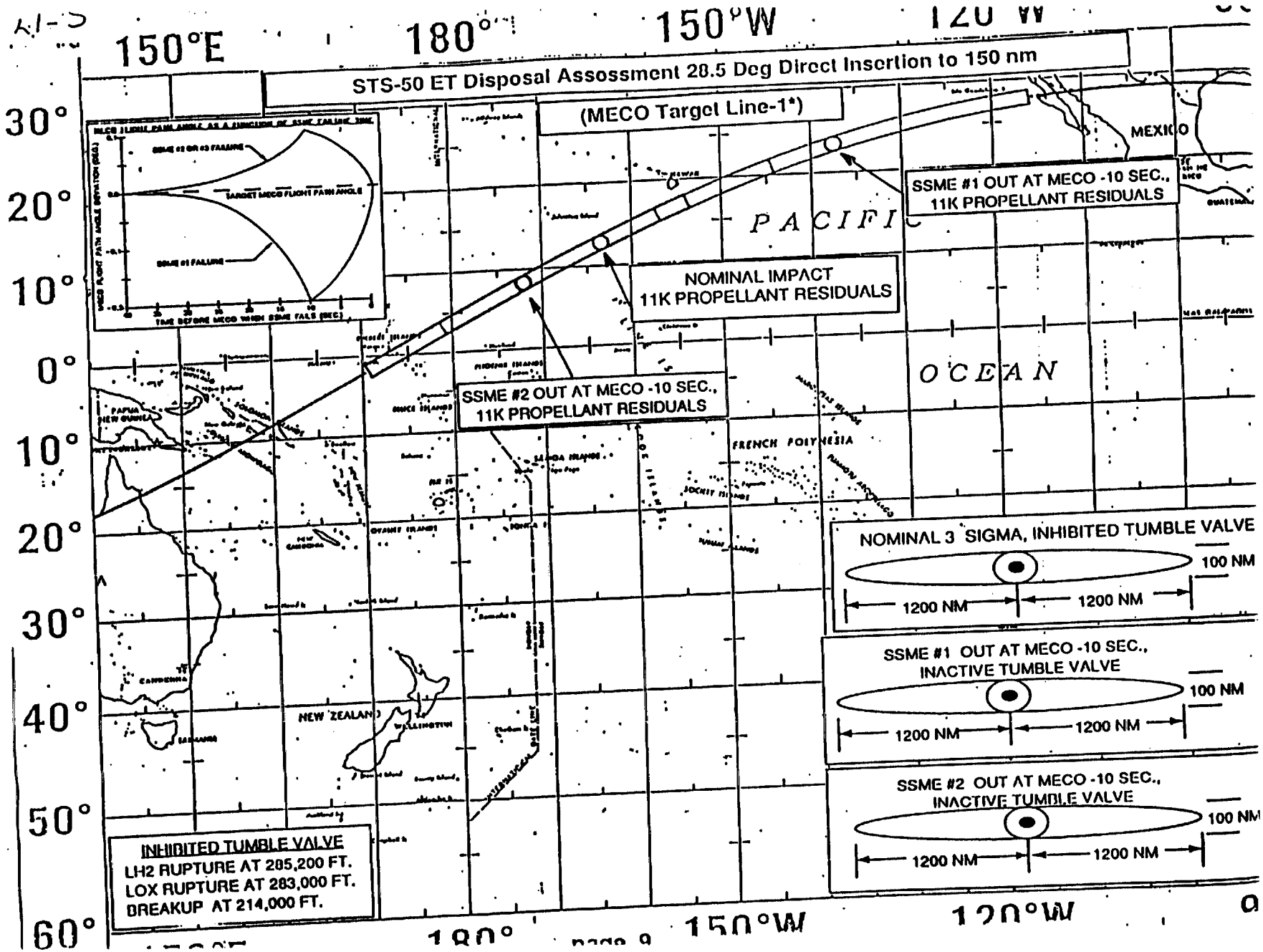
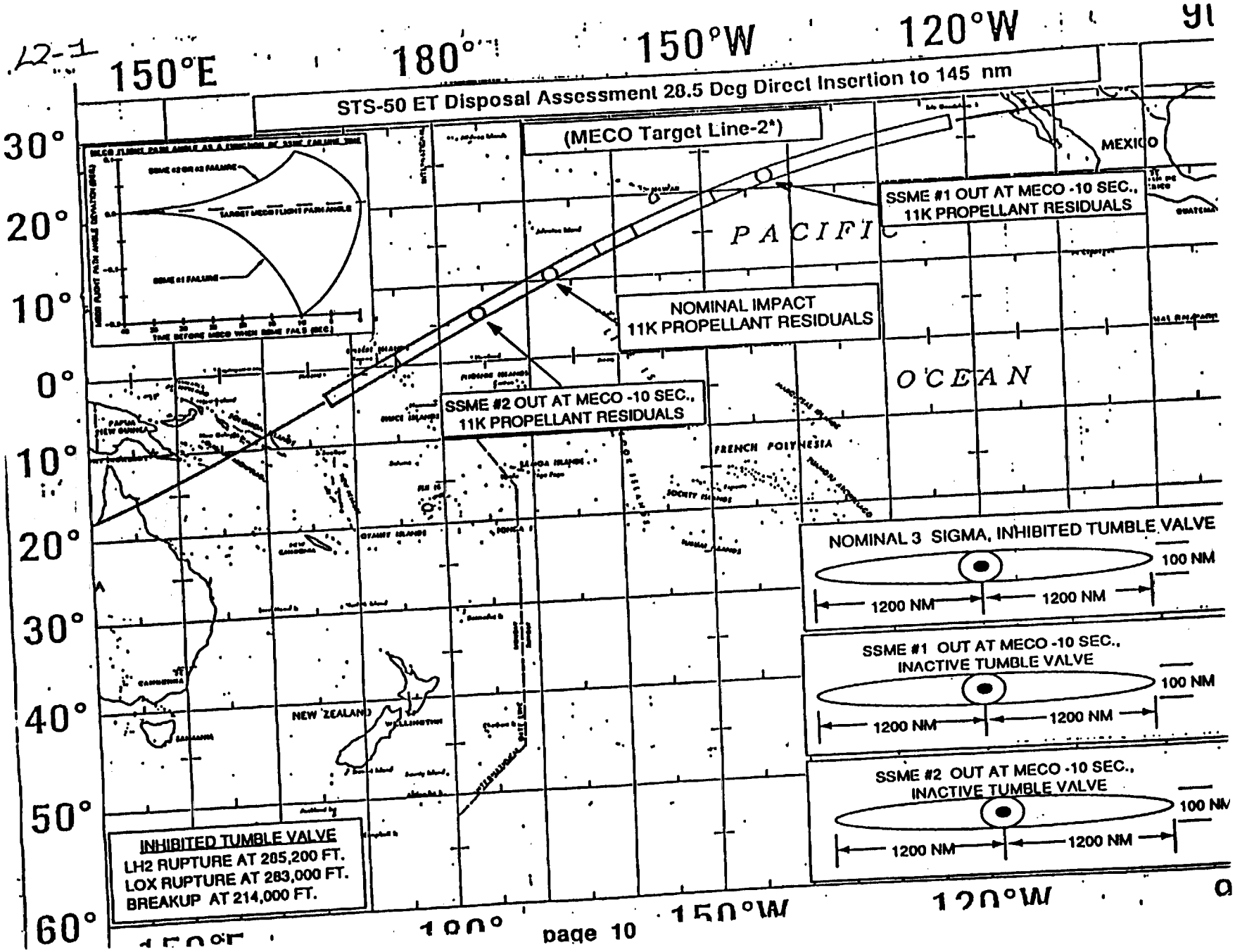
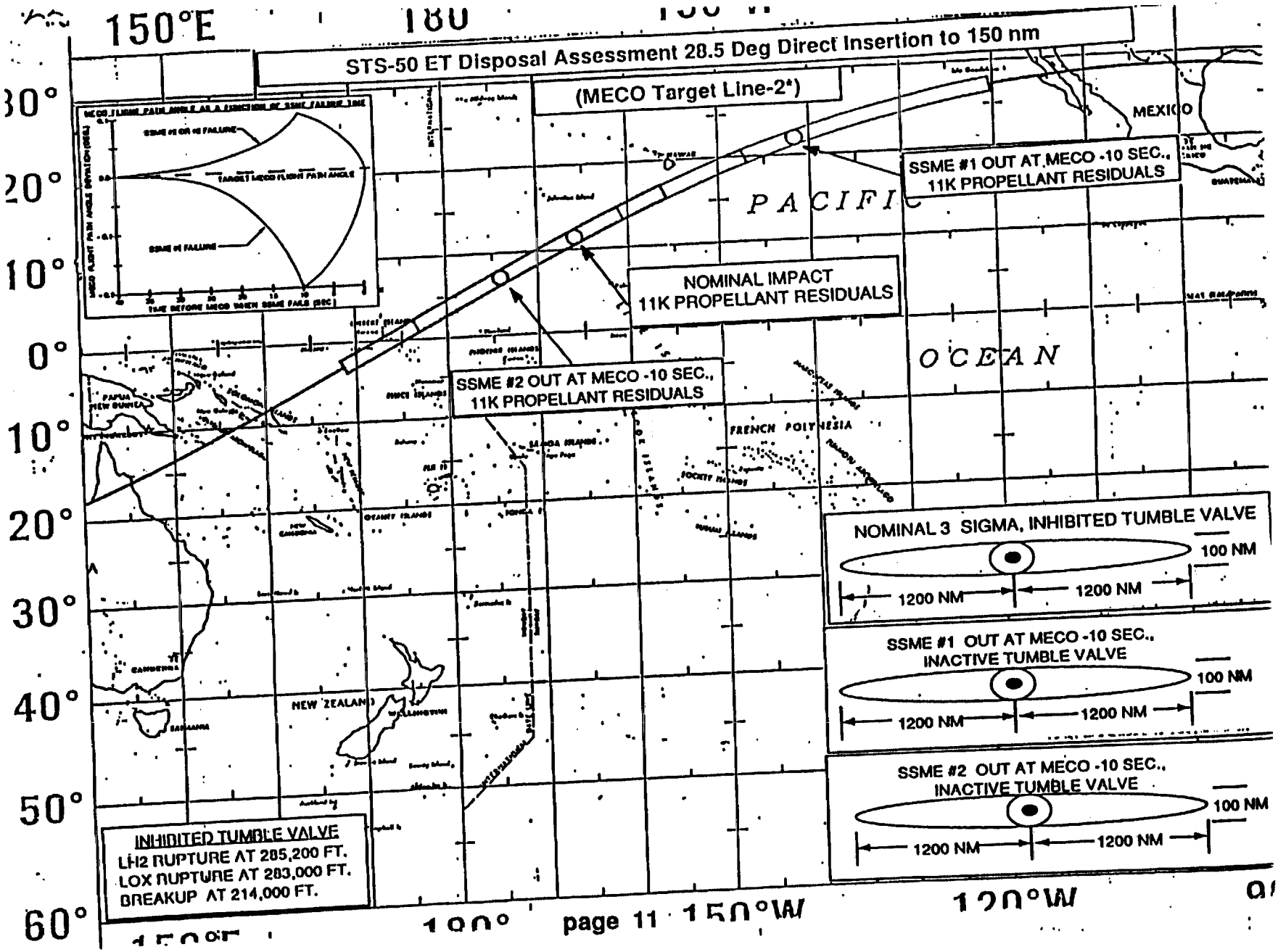

STS-50 ET Disposal Assessment 28.5 Deg Direct Insertion to 140 nm
(MECO Target Line-1°)
150°E
180°
150°W
120°W
30°
20°
10°
0°
10°
20°
30°
40°
50°
PACIFIC
OCEAN
MEXICO
FRENCH POLYNESIA
NEW ZEALAND
SSME #1 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL IMPACT 11K PROPELLANT RESIDUALS
SSME #2 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL 3 SIGMA, INHIBITED TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #1 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #2 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
1200 NM
1200 NM
INHIBITED TUMBLE VALVE
LH2 RUPTURE AT 285,200 FT.
LOX RUPTURE AT 283,000 FT.
BREAKUP AT 214,000 FT.


STS-50 ET Disposal Assessment 28.5 Deg Direct Insertion to 145 nm
(MECO Target Line-1*)
150°E
180°
150°W
120°W
30°
20°
10°
0°
10°
20°
30°
40°
50°
60°
MECO FLIGHT PATH ANGLE AS A FUNCTION OF SSME FAILURE TIME
SSME #2 OR #3 FAILURE
TARGET MECO FLIGHT PATH ANGLE
SSME #1 FAILURE
MECO FLIGHT PATH ANGLE DEVIATION (DEG)
TIME BEFORE MECO WHICH SSME FAILS (SEC)
SSME #1 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL IMPACT 11K PROPELLANT RESIDUALS
SSME #2 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
PACIFIC
OCEAN
MEXICO
FRENCH POLYNESIA
NEW ZEALAND
CANBERRA
WELLINGTON
NOMINAL 3 SIGMA, INHIBITED TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #1 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #2 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
INHIBITED TUMBLE VALVE
LH2 RUPTURE AT 285,200 FT.
LOX RUPTURE AT 283,000 FT.
BREAKUP AT 214,000 FT.


STS-50 ET Disposal Assessment 28.5 Deg Direct Insertion to 150 nm
(MECO Target Line-1*)
150°E
180°
150°W
120°W
30°
20°
10°
0°
10°
20°
30°
40°
50°
60°
SSME #1 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL IMPACT 11K PROPELLANT RESIDUALS
SSME #2 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
PACIFIC
OCEAN
MEXICO
FRENCH POLYNESIA
NEW ZEALAND
WELLINGTON
CANBERRA
NOMINAL 3 SIGMA, INHIBITED TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #1 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #2 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
INHIBITED TUMBLE VALVE
LH2 RUPTURE AT 285,200 FT.
LOX RUPTURE AT 283,000 FT.
BREAKUP AT 214,000 FT.

12-1


STS-50 ET Disposal Assessment 28.5 Deg Direct Insertion to 145 nm
(MECO Target Line-2*)
150°E
180°
150°W
120°W
30°
20°
10°
0°
10°
20°
30°
40°
50°
60°
MEXICO
PACIFIC
OCEAN
FRENCH POLYNESIA
NEW ZEALAND
SSME #1 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL IMPACT 11K PROPELLANT RESIDUALS
SSME #2 OUT AT MECO -10 SEC., 11K PROPELLANT RESIDUALS
NOMINAL 3 SIGMA, INHIBITED TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #1 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
SSME #2 OUT AT MECO -10 SEC., INACTIVE TUMBLE VALVE
100 NM
1200 NM
1200 NM
INHIBITED TUMBLE VALVE
LH2 RUPTURE AT 205,200 FT.
LOX RUPTURE AT 283,000 FT.
BREAKUP AT 214,000 FT.



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SUPERHEAVYWEIGHT MISSIONS
SI vs DI
ASCENT FLIGHT DESIGN
OPTIONS AND RECOMMENDATIONS

OCTOBER 26,1990

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R. LAMBERT/ RSOC
M. ELSPERMAN/ RSOC

E.BELL / RSOC
R. LAMBERT / RSOC
M. ELSPERMAN / RSOC

ACKNOWLEDGEMENTS

THIS ANALYSIS IS THE RESULT OF THE OUTSTANDING EFFORT OF SEVERAL ASCENT FLIGHT DESIGN PERSONNEL. THEIR WORK ON THIS STUDY IS GREATLY APPRECIATED.

ED BELL / RANGE SAFETY

ROXANNE LAMBERT / NOMINAL ASCENT

DAVE BRUECKMAN / RANGE SAFETY

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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TRADE STUDY RATIONALE

- ESMC RANGE SAFETY RELUCTANT TO APPROVE DUE EAST SI FLIGHTS AT CURRENT DESIGN UNDERSPEED
  - DESIGN UNDERSPEED RESULTS IN ET IMPACT ON AFRICA
  - RECENT HAZARD ANALYSIS SHOWS INCREASE IN CASUALTY EXPECTATION FOR DESIGN UNDERSPEED
- SI DESIGN UNDERSPEED MUST BE DECREASED TO PROTECT AFRICA (240 FPS DOWN TO 40 FPS)

OR

- USE DI FOR ALL DUE EAST MISSIONS

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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M. ELSPERMAN / RSOC

TRADE STUDY OBJECTIVES

- DEFINE/RECOMMEND AFD STRATEGY FOR SUPERHEAVYWEIGHT DI ≤ 160 n.mi. DUE EAST – e.g. EDO MISSIONS
- APPLY STRATEGY GENERICALLY TO ALL UPCOMING DUE EAST SUPERHEAVYWEIGHT MISSIONS
  - — HOW LOW CAN WE FLY DI?
  - — HOW HEAVY CAN WE BE?

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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M. ELSPERMAN / RSOC

STS-50 RESULTS

- INITIALLY EVALUATED STS-50 SPECIFICALLY FOR DI ≤ 160 n.mi. FIRST EDO MISSION (SUPERHEAVYWEIGHT)
- DETAILED PERFORMANCE ASSESSMENT INDICATED SUFFICIENT PERFORMANCE TO ACHIEVE DI 160 n.mi.
- RECOMMENDED DI 160 n.mi. AT STS-50 FOP (10/2/90)
- CONTINUE GENERIC ANALYSIS OF DI ≤ 160 n.mi. FOR APPLICABILITY TO OTHER SUPERHEAVYWEIGHT MISSIONS

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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M. ELSPERMAN / RSOC

METHOD FOR DEFINING STRATEGY

- EVALUATE/QUANTIFY PERFORMANCE SENSITIVITIES

STEP 1:

— RESEARCH BACKGROUND ON GENERIC DI/SI 160 N.MI. CUTOFF POINT

STEP 2:

— DEVELOP DUE EAST DIRECT INSERTION (DI) LOW ALTITUDE (≤ 160 n.mi) MECO TARGETS

STEP 3:

— GENERATE/ANALYZE PERFORMANCE CAPABILITIES

STEP 4:

— RECOMMEND PROCEDURE FOR SUPERHEAVYWEIGHT MISSION PLANNING

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STEP 1

GENERIC DI / SI CUTOFF POINT BACKGROUND

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SI vs DI

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CUTOFF POINT BACKGROUND

- NO DEFINITIVE DOCUMENT EXPLAINING 160 N.MI. CUTOFF FOR DUE EAST SI/DI

- CONTACTED SEVERAL PERSONS INVOLVED IN RANGE SAFETY WORK EARLY IN STS PROGRAM

D. SEAL	M. HENDERSON
P. ROBINSON	D. IVES
B. BLACKSTOCK	J. WOLFE
G. VENABLES	B. CONTE
D. BRUECKMAN	A. BORDANO

- ALL CONCURRED THAT 160 N.MI. WAS AN ARBITRARY CUTOFF POINT
  - — CONSERVATIVE ET IMPACT PROTECTION
  - — PERFORMANCE INDEPENDENT
  - — SIMPLIFIED MISSION PLANNING

- ASSUMED ET IMPACT PROBLEMS FOR DUE EAST DI $\leq$ 160 N.MI.
  - — TRUE IF APPLIED GENERICALLY
  - — NOT TRUE IF PERFORMANCE CRITICAL (LOW RESIDUALS)

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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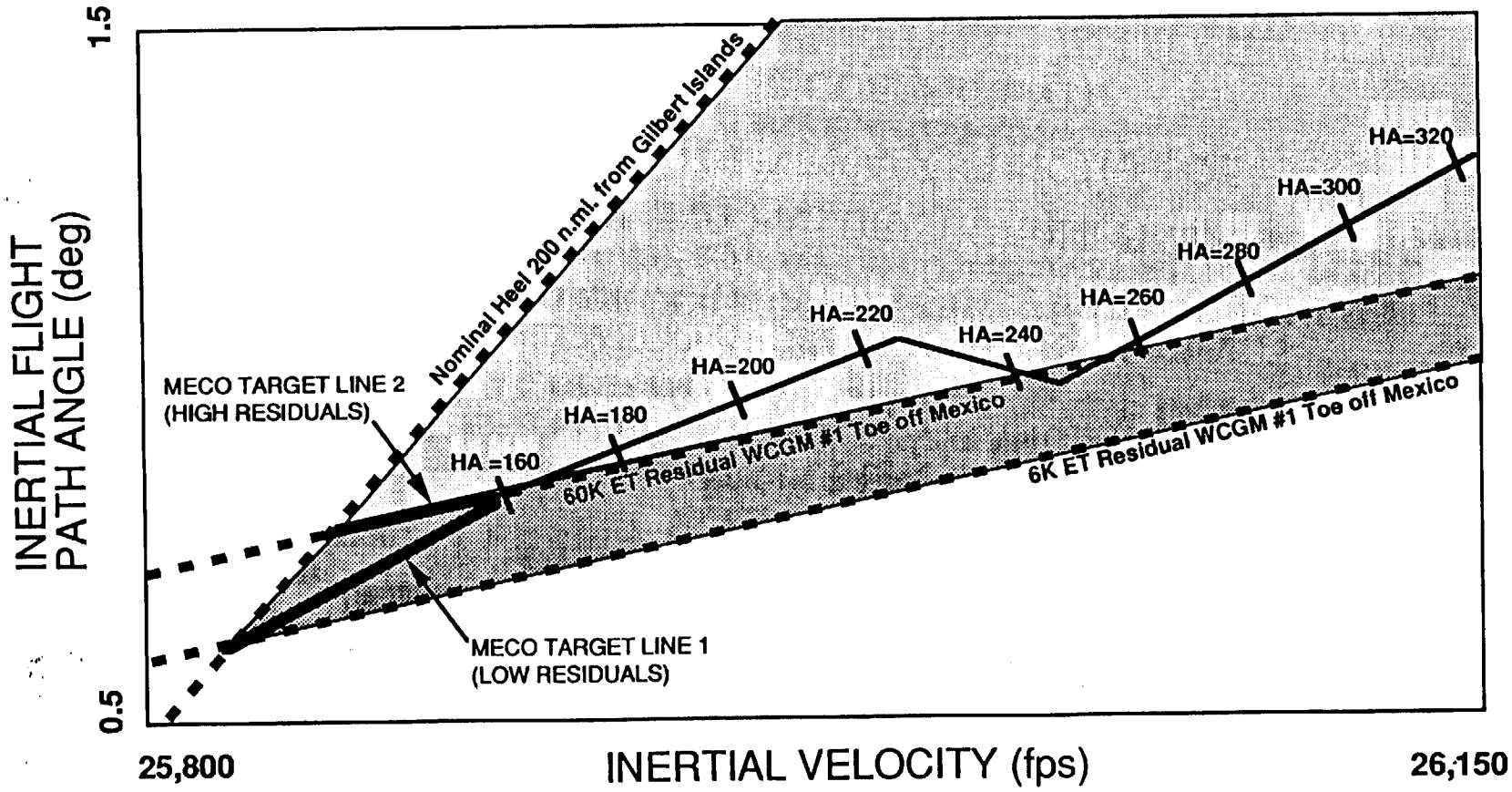
DI MECO TARGET/CONSTRAINT LINES FOR DUE EAST LAUNCHES



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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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MECO TARGET
CONSTRAINT LINES ARE DEPENDENT ON ET BALLISTIC COEFFICIENT

- GILBERT ISLAND CONSTRAINT LINE ENSURES THAT ET FOOTPRINT HEEL HAS 200 N.MI. CLEARANCE NOMINALLY
- WORST CASE GUIDED MECO (WCGM) CONSTRAINT LINES ENSURE ET IMPACT OFF OF BAJA FOR DUE EAST LAUNCHES (GAMMA ERROR FOR SSME #1 FAILURE DURING FINE COUNTDOWN)
- WCGM TARGET CONSTRAINT LINES ARE FUNCTION OF ET WEIGHT AT MECO (BALLISTIC COEFFICIENT)
  - — ATMOSPHERIC DRAG CAUSES LIGHT ET TO IMPACT UPRANGE OF HEAVY ET FOR GIVEN VELOCITY/GAMMA
- TARGETING TO 60K CONSTRAINT LINE ENSURES THAT WCGM IMPACT IS ALWAYS OFF BAJA REGARDLESS OF ET RESIDUAL - CONSERVATIVE

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

E.BELL / RSOC
R. LAMBERT / RSOC
M. ELSPERMAN / RSOC

DI 160 MECO TARGET IS PERFORMANCE INDEPENDENT

- DI 160 n.mi. MECO TARGET IS POINT ON 60K RESIDUAL WCGM CONSTRAINT LINE
- DI 160 n.mi. MECO TARGET RESULTS IN ADEQUATE NOMINAL ET FOOTPRINT CLEARANCE OF GILBERT ISLANDS REGARDLESS OF ET RESIDUAL (PERFORMANCE INDEPENDENT)
- DI 160 n.mi. MECO TARGET ENSURES THAT BAJA IS ALWAYS PROTECTED FOR WCGM REGARDLESS OF ET RESIDUAL (PERFORMANCE INDEPENDENT)
- CURRENT DI 160 n.mi. MECO TARGET IS CONSERVATIVE

E.BELL / RSOC
R. LAMBERT / RSOC
M. ELSPERMAN / RSOC

STEP 2

MECO TARGET GENERATION FOR DI $\leq$ 160 n.mi.

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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R. LAMBERT / RSOC
M. ELSPERMAN / RSOC

GROUNDRULES AND ASSUMPTIONS FOR MECO TARGET DERIVATION

- DUE EAST DI MECO TARGET/CONSTRAINT LINES USED AS BASELINE
- MECO TARGET LINE 1

  INTERPOLATION BETWEEN 60K RESIDUAL CONSTRAINT LINE AND 6K CONSTRAINT LINE
- MECO TARGET LINE 2

  SMALL SEGMENT OF 60K RESIDUAL CONSTRAINT LINE
- CONSERVATIVE IMPACT ELLIPSE

  ± 1200 N.MI. BY ±50 N.MI
- 11K RESIDUALS ASSUMED
- RUPTURE AND BREAKUP ALTITUDES CONSISTENT

  285K RUPTURE
  214K BREAKUP

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

E.BELL / RSOC
R. LAMBERT / RSOC
M. ELSPERMAN / RSOC

DUE EAST DI ≤ 160 IS ACCEPTABLE FOR PERFORMANCE CRITICAL MISSIONS

- LOW RESIDUAL ASSUMPTION ALLOWS SHALLOWER GAMMA/HIGHER VELOCITY MECO TARGET
- NOMINAL ET IMPACT POINT IS FURTHER DOWNRANGE
- WCGM FOOTPRINT MIGHT COVER BAJA - MISSION SPECIFIC ANALYSIS REQUIRED (DEPENDEDNT ON APOGEE ALTITUDE AND RESIDUAL)
- PERFORMANCE CRITICAL MISSIONS (LOW RESIDUALS) CAN SAFELY DI TO ≤ 160 N.MI.

APOGEE ALTITUDE (n.mi.)	SMALL RESIDUAL TARGET ET FOOTPRINT GILBERT ISLAND CLEARANCE (n.mi.)	LARGE RESIDUAL TARGET ET FOOTPRINT GILBERT ISALND CLEARANCE (n.mi.)
130	258.0	- - - - -
140	308.3	- - - - -
145	349.8	108.2
150	349.8	201.2

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STEP 3

PERFORMANCE CAPABILITY EVALUATION

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SUPERHEAVYWEIGHT MISSIONS
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PERFORMANCE ASSESSMENT GROUNDRULES AND ASSUMPTIONS

- STS-50 AFP TDDP (AFPAF50)
- OV-102 (EDO MODS) w/ USML-1 PAYLOAD
- 670 Q/-3250 SUMMER ASCENT DESIGN CRITERIA (LOW Q)
- JUNE DESIGN MONTH (PMBT = 77°)
- SI-145 MECO TARGET - OMS LOAD = 18600 lbs
- FLIGHT DERIVED SSME PERFORMANCE MODEL
- SRB PERFORMANCE MODEL: TC-LT-R236-89-NOM
- i = 28.45°

SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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PERFORMANCE ENHANCEMENT OPTIONS

- LOW Q vs HIGH Q 1ST STAGE DESIGN
  - — TRADE LAUNCH PROBABILITY vs ASCENT PERFORMANCE MARGIN
- ORBITAL ALTITUDE
  - — TRADE ALTITUDE vs ASCENT PERFORMANCE MARGIN
- ELLIPTICAL ORBIT
  - — REDUCES ORBITAL INSERTION Δ V BUT INCREASES DEORBIT ΔV (DEORBIT FROM PERIGEE REQUIREMENT)
  - — PAYLOAD COMPATIBILITY REQUIRED

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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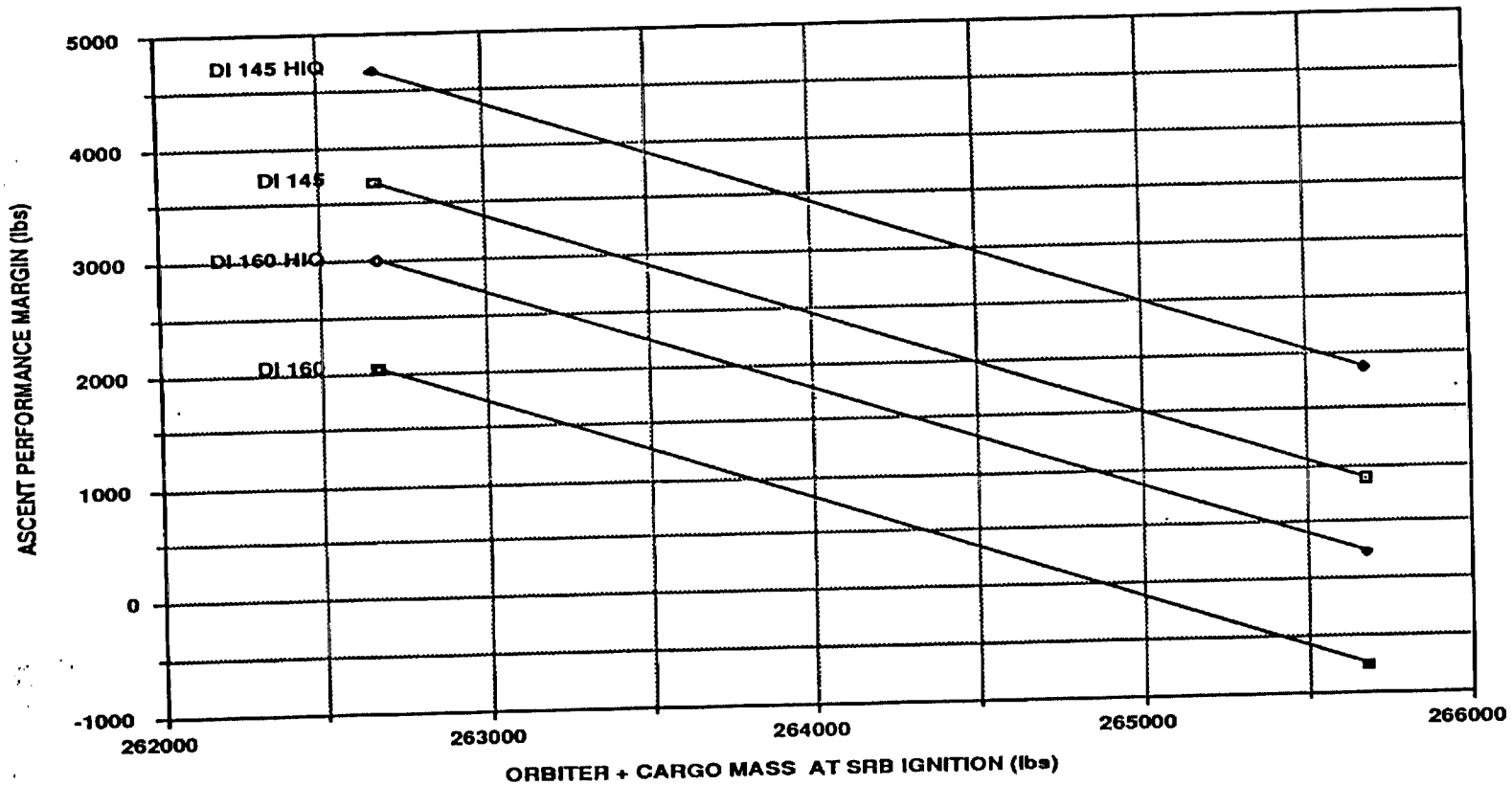
DIRECT INSERTION PERFORMANCE (FOR EARLY ASSESSMENT ONLY)

SUPERHEAVYWEIGHT PERFORMANCE TRENDS



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STEP 4

CONCLUSIONS AND RECOMMENDATIONS

SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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SI vs DI SUPERHEAVYWEIGHT MISSIONS GENERIC CONCLUSIONS

- ASSUMPTION THAT DI ≤ 160 n.mi. NOT POSSIBLE IS CONSERVATIVE
  - PROVIDED LARGE IMPACT PROTECTION
  - INDEPENDENT OF PERFORMANCE (LARGE OR SMALL RESIDUALS)
  - ALLOWED FOR SIMPLIFIED MISSION PLANNING
- DI ≤ 160 n.mi. ACCEPTABLE IF PERFORMANCE CRITICAL (SMALL RESIDUALS)
  - SUPERHEAVYWEIGHT MISSIONS e.g. EDO FLIGHTS
  - SHALLOWER GAMMA/LARGER VELOCITY MECO TARGET MOVES ET FOOTPRINT DOWNRANGE
- DI ≤ 160 n.mi. NOT ACCEPTABLE IF NON-PERFORMANCE CRITICAL (LARGE RESIDUALS)
- GENERIC CUTOFF POINT FOR SI/DI NOT APPLICABLE TO SUPERHEAVYWEIGHT MISSIONS
  - MISSION SPECIFIC ANALYSIS IS REQUIRED TO DETERMINE FEASIBILITY OF DI ≤ 160 n.mi. (PERFORMANCE DEPENDENT)

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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MANIFEST DECISION CRITERIA AND RECOMMENDATIONS

- PERFORM AN EARLY PERFORMANCE ASSESSMENT FOR ALL DUE EAST SUPERHEAVYWEIGHT MISSIONS e.g. EDO

  1) DI 160 n.mi. LOW Q

  2) DI ≤ 160 n.mi LOW Q
     (TRADE ALTITUDE FOR PERFORMANCE)

  3) DI 160 n.mi. HIGH Q
     (TRADE LAUNCH PROBABILITY FOR PERFORMANCE)

  4) DI ≤ 160 n.mi. HIGH Q
     (TRADE ALTITUDE AND LAUNCH PROBABILITY FOR PERFORMANCE)

- EVALUATE ELLIPTICAL ORBIT OPTION ON A MISSION UNIQUE BASIS (PAYLOAD COMPATIBILITY RQD)

- VARIABLES AFFECTING PERFORMANCE MARGIN WILL AFFECT ABILITY TO FLY DUE EAST DI ≤ 160 n.mi.

  SEASONAL CHANGES
  C.G. BALLASTING
  SYSTEM WEIGHT CHANGES
  MISSION DURATION
  LOW PERFORMING ENGINES

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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BACKUP CHARTS

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SUPERHEAVYWEIGHT MISSIONS
SI vs DI

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DI MECO TARGET/CONSTRAINT LINES FOR DUE EAST LAUNCHES

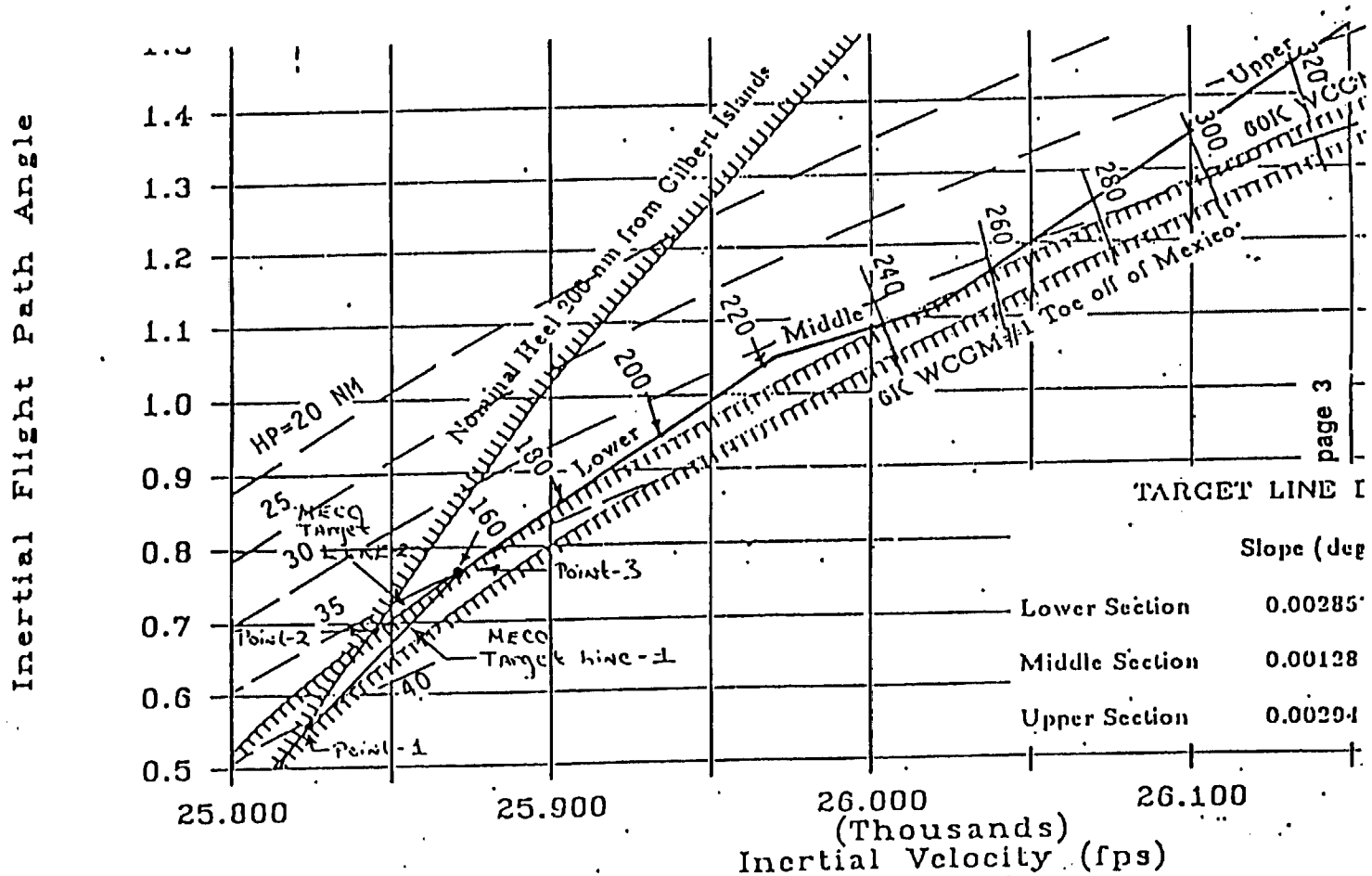

TABLE 4: MECO TARGET LINES EXTENSION DATA

POINT	VI (fps)	APOGEE ALTITUDE via Orbital Program (nm)	APOGEE ALTITUDE with MPS (nm)
1	25,823	124.2093	128.0232
2	25,845	140.9582	144.7721
3	25,870	155.9152	159.7292

STS-26 APOGEE ALTITUDE = 156.19 nm

BAIS = (160-156.19) = 3.81 nm

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